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Mid-Atlantic Integrated Assessment

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I. Invited Speakers

Nitrate and Selected Pesticides in Ground Water of the Mid-Atlantic Region

Scott W. Ator¹, Matthew J. Ferrari¹, and Thomas Pheiffer²

¹U.S. Geological Survey, 8987 Yellow Brick Road, Baltimore, MD 21237

²U.S. Environmental Protection Agency, 201 Defense Highway, Suite 200, Annapolis, MD 21401

Data collected from more than 850 sites between October, 1985 and September, 1996 (inclusive) were compiled and analyzed to document the occurrence of nitrate and pesticides in ground water of the Mid-Atlantic region. Nitrate was detected in nearly three-quarters of the samples for which it was analyzed, commonly at levels that suggest anthropogenic sources. Ten percent of samples contained nitrate at concentrations exceeding the Federal Maximum Contaminant Level (MCL) of 10 milligrams per liter as nitrogen. Pesticide compounds (including atrazine, metolachlor, prometon, simazine, and desethylatrazine, an atrazine degradate) were detected in about half of the samples for which they were analyzed, but rarely at concentrations exceeding established MCL's. The most commonly detected pesticide compounds were desethylatrazine and atrazine.

The occurrence of nitrate and pesticides in ground water of the Mid-Atlantic region is related to land cover and rock type. Likely sources of nitrate and pesticides to ground water include agricultural and urban land-use practices; rock type affects the movement of these compounds into and through the ground-water system. Nitrate concentrations in the compiled data set are significantly higher in ground water in agricultural areas than in urban or forested areas. Detection frequencies of atrazine, desethylatrazine, and simazine are indistinguishable among urban areas, row crops, and pastures. Prometon was most commonly detected in ground water in urban areas. Concentrations of nitrate and detection frequencies of pesticides were significantly higher in samples from carbonate rocks than in those from any other rock type.

Pesticides in Surface Waters in the Mid-Atlantic Integrated Assessment Region

Matthew J. Ferrari, Scott W. Ator, and Joel D. Blomquist

U.S. Geological Survey, WRD, 8987 Yellow Brick Road, Baltimore, MD 21237

Data for more than 2500 samples from 463 sites were compiled and analyzed to document the occurrence and distribution of pesticides in surface waters of the Mid-Atlantic region as part of the Mid-Atlantic Integrated Assessment program of the U.S. Environmental Protection Agency. Only those data collected by the U.S. Geological Survey between October, 1973 and December, 1996 (inclusive) were used in the analysis. Most of the available data were collected since 1992, and more samples were collected during the months of the growing season, April through September, than during other months. Data are available for most of the Mid-Atlantic region, but large spatial gaps in available data do exist.

Data are available for 127 compounds, including 12 degradates; but only 16 compounds were detected in more than 100 samples. Atrazine and metolachlor were the most frequently detected compounds, in more than 70 percent of samples. Concentrations of atrazine exceeded the Federal Maximum Contaminant Level (MCL) for drinking water of 3 $\mu\text{g/L}$ (micrograms per liter) in 67 of 2077 samples from 15 sites. MCL's for alachlor (2 $\mu\text{g/L}$) and simazine (4 $\mu\text{g/L}$) were exceeded in 13 and 18 samples, respectively.

Data from the 32 most frequently sampled sites were used to determine seasonal patterns and temporal variability. Pesticide occurrences in these surface-water sites were also related to land use in the contributing watersheds. Median concentrations of several compounds, such as diazinon and chlorpyrifos, were found to be highest in watersheds with a significant percentage of urban land.

The Bird Community Index: A Tool for Assessing Biotic Integrity in the Mid-Atlantic Highlands

Timothy J. O'Connell¹, Laura E. Jackson², and Robert P. Brooks¹

¹Penn State Cooperative Wetlands Center, Forest Resources Laboratory, Pennsylvania State University, University Park, PA 16802.

²U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC 27711

As part of the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (EMAP), we developed an indicator of biotic integrity based on songbird community composition. Because songbirds occur in a wide variety of habitat types, the bird community index (BCI) is intended to integrate ecological conditions across a large physiographic region exhibiting diverse land-cover attributes and intensities of human use. Comprised of multiple biological metrics, our indicator is an index that ranks bird communities according to the proportional representation of 16 behavioral and physiological response guilds. Relative proportions of "specialist" and "generalist" guilds, viewed as indicators of structural, functional, and compositional ecosystem elements, determine condition. We developed the BCI from 34 reference sites in central Pennsylvania that represent a gradient of ecosystem condition from near pristine to severely degraded. Upon satisfactory demonstration that the BCI could discriminate between categories of ecosystem condition, we applied the BCI to independent samples of 126 sites across the Mid-Atlantic Highlands Assessment (MAHA) area. Sites were selected using EMAP's probability-based sampling design, and therefore represent the total land area in the region. To verify the BCI's discriminatory properties, we compared the BCI assessment to independent gradients of landscape disturbance applied to both the 34 reference sites and the 126 MAHA sites. The BCI identified four categories of biotic integrity in the MAHA area. Our assessment indicated that 16% of the area is in "excellent" condition, 27% is "good", 36% is "fair", and 21% is in "poor" condition. Urban and agricultural sites differ in their respective guild compositions, but are not separable by overall BCI score. Forested sites supporting the two highest-integrity categories contain different site-level vegetation attributes, but cannot be separated by landscape-level land-cover composition. This research also defined thresholds of land-cover change where significant shifts in BCI categories were observed.

Integrated Estuarine Monitoring in the Mid-Atlantic

Barbara S. Brown¹ and J. Kevin Summers²

¹U.S.EPA, Atlantic Ecology Division, 27 Tarzwell Drive, Narragansett, RI 02882

²U.S. EPA, Gulf Ecology Division, Sabine Island, Gulf Breeze, FL 32561

There is currently no comprehensive scientific basis to assess the ability of the natural environment to continue to meet human needs. The Committee on the Environment and Natural Resources highlighted the need for a national framework to integrate ongoing environmental monitoring programs in a cost efficient way to produce comparable data to improve both environmental policy and scientific understanding. In 1997 and 1998, the Mid-Atlantic Integrated Assessment (MAIA) program began a coordinated monitoring effort of the mid-Atlantic estuaries to demonstrate that effective partnerships could be established among Federal and State agencies with estuarine responsibilities. This coordinated effort was intended to fill data gaps in characterizing the ecological condition of the MAIA estuaries and determine better monitoring approaches for small systems. Monitoring was based on two principles: agreement on a common set of measures, and integration of the partners' existing sampling stations. In 1997, approximately 900 stations were sampled by the partners, with primary emphasis on water and sediment quality. In 1998, approximately 700 stations were sampled by the partners for water quality parameters. In addition, a subset of the stations sampled in 1997 were revisited by EPA's Atlantic Ecology Division and sampled for contaminants in fish. This effort showed that integration of existing sampling programs can be successful, but requires substantial commitment and commitment and communication among participants. Further work is needed to institutionalize consistent sampling methods and expand the partners' monitoring programs to include contaminants in fish.

Geographic Analyses of Species Richness and Community Attributes of Forest Birds from Survey Data in the Mid-Atlantic Integrated Assessment (MAIA) Region

Emmanuelle Cam, John R. Sauer and James D. Nichols

USGS Patuxent Wildlife Research Center, 11510 American Holly Drive, Laurel, MD 20708-4017

As part of an assessment of the condition of forests in the Mid-Atlantic Integrated Assessment (MAIA) Region, we have been using data from the North American Breeding Bird Survey (BBS) to estimate spatial and temporal change in community attributes of forest-breeding birds. Although bird survey data are limited because species are missed during counting, recently-developed methods for estimation of community attributes such as species richness can be used to provide unbiased estimates of spatial and temporal patterns of extinction, colonization, and biotic integrity of species. We describe these methods, their application to bird data from the MAIA region, and present some preliminary data on the association of bird community attributes with remotely-sensed habitat data.

Estimates have been made for each BBS route in five states: Delaware, Maryland, Pennsylvania, Virginia, West-Virginia. We focused on two groups of birds: forest birds, and area-sensitive forest birds. “Area-sensitivity” was used as a criterion to characterize “interior-forest” birds. Depending on the data available for each BBS route, species richness has been estimated for the largest number of years within the 1975-1990 period (i.e., 16 estimates are available for the routes that have been run each year). Extinction probability and turnover between 1975 and 1990 have been estimated for the species groups on each BBS route in the five states. The Breeding Bird Survey routes have been digitized (the path of each route), and estimates of species richness (forest birds and interior forest birds), estimates of extinction probability, and of species turnover have been mapped for the two groups of species. We have also evaluated the association between bird community integrity and amount of urbanization adjacent to the survey route, and generally document negative associations.

Large Scale Amphibian Monitoring in the Mid-Atlantic: Power to the People

Sam Droege¹ and Paige Eagle²

¹USGS - Patuxent Wildlife Research Center, Laurel, MD 20708-4038

²3636 Francis Avenue N., Apt. 301, Seattle, WA 98103

Both the presence and the absence of amphibian declines in the Mid-Atlantic region are greatly exaggerated. Little is known of the current status or trajectory for most species other than all the species historically known from the region are still present. However, large scale probabilistic surveys for amphibians are being developed for the region to provide the quantitative evidence needed to document population change. Calling surveys for anurans are planned for all states in the Mid-Atlantic, identification materials, identification tests, hearing tests, online data entry, and data access are in preparation. An online bibliography with keyword searches is now available at <http://monitoring2.pwrc.nbs.gov/amphibs/> for references and web sites. These surveys will use volunteer observers. Volunteers have the ability to accurately identify species, produce surveys with consistent results (i.e., low CV's), have long tenure on surveys (unlike technicians), and cost nothing.

Pilot data and published counts of amphibians using a large variety of techniques were evaluated for count variation and the impacts of that variation on sample size and replication requirements. The average coefficient of variation for all techniques applicable in the North East is 40% (n=42) and 62% (n=70) in the Southeast. Few natural history or methodological patterns were evident. Variation across years in counts of an individual species can range from very high to very low even within single studies. Most of the highest variation was associated with counts from temporary pool environments that had no or low reproduction in some years. Low variation was associated with a number of species groups with terrestrial and stream side salamander counts averaging lower than others (<http://WWW.MP1-PWRC.USGS.GOV/powcase/powcase.html>).

The use of presence/absence of amphibians at a site was a great tamer of CV's. CV's varied from 3% to 43% with an average of 20% on calling surveys based on frequency in ecoregions of Wisconsin.

Assessment of Forest Disturbance in the Mid-Atlantic Region: A Multi-Scale Linkage Between Terrestrial and Aquatic Ecosystems

Keith N. Eshleman

University of Maryland Center for Environmental Science, Appalachian Laboratory, Frostburg, MD 21532

The objective of this project is to develop, test, validate, and demonstrate an analytical framework for assessing regional-scale forest disturbance in the mid-Atlantic region by establishing a multi-scale linkage between forest disturbance and forest nitrogen export to surface waters. It is hypothesized that excessive nitrogen (N) leakage (export) from forested watersheds is a potentially useful, integrative “indicator” of a negative change in forest function which occurs in synchrony with changes in forest structure and species composition. Our research focuses on forest disturbance associated with recent defoliations by the gypsy moth larva at spatial scales ranging from small watersheds to the entire region. By combining data from intensively-monitored watersheds describing forest N leakage resulting from gypsy moth defoliation with spatially-extensive data describing the distribution of forest species in the mid-Atlantic region, the spatial pattern of gypsy moth disturbances to forested areas, and survey measurements of dissolved N species in surface water, an approach for assessing the magnitude of forest disturbance and its impact on surface water quality will be demonstrated. The project will thus effectively provide a multi-resource linkage between forests and surface waters in the mid-Atlantic region using data and models assembled from (1) watershed-scale studies of intensively-studied systems, (2) synoptic-scale surveys of resource conditions (including soils, forests, surface waters, etc.), and (3) remotely-sensed information.

A major task of the project is the incorporation of disturbance into a useful model of N export from forests to receiving surface waters. It has been shown that N export due to a single disturbance can be empirically described using a linear impulse response function model known as the UNERF (Unit Nitrogen Export Response Function) and that N export from multiple disturbances can thus be described using the convolution integral. Actual N export time series for disturbed, intensively-monitored watersheds have the same general shape, characterized by a rather steep increase in export beginning shortly after the time of disturbance, a peak N export rate occurring 1-2 years after disturbance, and a recession to normal baseline levels over several years following the peak. Though it is believed that the UNERF model parameters likely vary as a function of forest type and by ecoregion, it is possible to make some gross assumptions about these parameters as a means of (1) illustrating the proposed analytical technique and (2) providing a first-order assessment of the importance of forest disturbances (relative to other point and non-point sources) as sources of N to receiving surface waters in the region. Results and uncertainties associated with the current assessment are discussed in the context of addressing this important watershed management issue.

A Hierarchical, Patch Dynamics Approach to the Long Term Study of Urban Ecological Systems: Baltimore, MD

Gary Fisher¹, Morgan Grove², and Steward Pickett³

¹US Geological Survey, 8987 Yellow Brick Road, Baltimore, MD 21237

²USDA Forest Service, Northeastern Forest Research Station, 705 Spear Street, South Burlington, VT 05403

³Institute of Ecosystem Studies Box AB (Route 44A), Millbrook, NY 12545-0129

Recognizing the need for the long term study of basic ecological processes, the National Science Foundation (NSF) established and has maintained a Long Term Ecological Research (LTER) network for nearly twenty years. Increasingly, however, biological ecologists have recognized the need for the explicit study of human ecological systems and of urbanization, which is a dominant type of global change. To address these needs, NSF established recently two urban LTERs in metropolitan regions: one centered around Baltimore, Maryland, the other around Phoenix, Arizona. Critical to these two LTERs is their ability to integrate dynamic physical, biological, and social systems in terms of structure and function; to include hierarchical scales of organization; and to analyze the spatial heterogeneity of these systems. In order to respond to these issues, both sites have adopted an hierarchical, patch dynamics approach even though the two sites are significantly different in terms of their pre-historic, historic, and present physical, biological, and social dynamics. This presentation is separated into two parts. The first part describes the conceptual and analytic basis for integrating physical, biological, and social systems through an hierarchical, patch dynamics approach to human ecological systems. The second part illustrates how this approach is being applied to the long term study and monitoring of the Baltimore metropolitan region.

Keywords: human ecology, urban, patch dynamics, Baltimore, Maryland

Perspective on Analysis and Research Integration Through the Baltimore-Washington Regional Collaboratory

Timothy W. Foresman

Director, Spatial Analysis Lab, University of Maryland, Baltimore County (UMBC)
Assistant Professor, Department of Geography and Environmental Systems
1000 Hilltop Circle, Baltimore, MD 21250

An experiment was initiated by the Spatial Analysis Laboratory of the University of Maryland, Baltimore County, in 1995 to determine the structural feasibility and potential applications for a regional spatial data management network. This spatial network, the Baltimore-Washington Regional Collaboratory, sponsored in part by NASA's office of Earth Science, has supported a series of outreach, education partnerships, and research activities dealing with ecological of regional data and users has been identified and linked to the Collaboratory. Results are pr, social, and physical science issues. A hallmark program of the Collaboratory has been the 200-year land use dynamics study conducted in cooperation with the United States Geological Survey (USGS) HILT program. Direct results of the Collaboratory include the NSF funded Baltimore Ecosystem Study (Long-Term Ecological Research) in cooperation with the United States Forest Service (USFS), USGS, and EPA; and the Urban-Rural Index in cooperation with the Chesapeake Bay office. A complex stratification presented in terms of the Web-based regional structure (systems and data architecture), and performance of the myriad outreach (regional community utilization), and research projects (data integration and synthesis).

URL: www.umbc.edu/bwrdc - Baltimore Washington Regional Collaboratory
baltimore.umbc.edu/lter - LTER

Evaluating Landscape Metrics as Indicators of Forest Ecosystem Health

Stephanie G. Fulton^{1,2}, George R. Hess¹, and Kenneth W. Stolte²

¹North Carolina State University, Forestry Department, Raleigh, NC 27695-8002

²USDA Forest Service, Southern Research Station, PO Box 12254, Research Triangle Park, NC 27709

Current landscape ecological theory holds that ecosystem structure affects, and may be predictive of, ecosystem function. This suggests that landscape metrics (e.g., percent forest cover, forest fragmentation) can be used to arrange forested ecosystems along a gradient of “ecosystem health.” However, correlations between landscape metrics and ecosystem condition and function have not been quantified extensively. The strength of these correlations will determine the utility of landscape metrics as measures of ecosystem health. The USDA Forest Service's Forest Health Monitoring Program has initiated work to quantify the correlations between landscape metrics and other measures of forest ecosystem health, including wildlife species richness, extinction rates, and turnover; and various measures of water quality.

We will present our conceptual model for an integrated landscape-level forest health assessment, illustrated by ongoing work toward quantifying the relationships among several landscape metrics and water quality parameters. Our model is hierarchical and describes a complex, interconnected landscape at multiple scales. Data are synthesized and analyzed at appropriate scales, as indicated by the conceptual model. We will use landscape metrics developed for 8-digit hydrologic units as part of the Mid-Atlantic Integrated Assessment (MAIA) and water quality data (e.g., sedimentation, benthic macroinvertebrate assemblages) collected as part of the Mid-Atlantic Highlands Assessment (MAHA). The MAHA data also include measures of landscape composition for the sample point basin. These data will allow us to evaluate the relationship between landscape composition and water quality at two scales. We will present preliminary results, highlight their implications, and make recommendations for further research.

Characteristics of Maryland Agriculture Relevant for Environmental Assessment

Ray Garibay

Maryland Agricultural Statistics Service, 50 Harry S Truman Parkway, Suite 202, Annapolis, MD 21401

This project is designed to assemble and present statistical data representing attributes of the Maryland agriculture production system relevant for assessment of the environmental benefits contributed by this critical food and fiber production sector of the economy. Agricultural statistics at the traditional county boundaries were aggregated to the watershed level permitting the first step toward evaluating agricultural production practices have on the environment.

The sources of the data series presented in this publication are primarily the Maryland Agriculture Statistics Service and the National Agricultural Statistics Service. In some cases the format of the data series were reconfigured to more effectively depict the various facets of agriculture and their environmental influence. Examination of the information presented in this publication are intended to provide both the general public and the scientific community with increased understanding of the role of agriculture in the quality of life in the ecosystem of the Mid Atlantic area and the Chesapeake Bay region and to make people more aware of the information tools for analysis of the situation currently available. The study attempts to illuminate heretofore unmined and unavailable areas of information development needed for complete analysis of the impact of the food production system on quality of life in the region.

The Central Appalachian Assessment: Opportunities for Ecological Restoration

Jason Halbert

Appalachian Restoration Campaign, PO Box 2786, Charlottesville, VA 22902-2786

Landscape-level analysis utilizing spatial data layers and GIS software may provide Appalachia opportunities for non-industrial economic growth by identifying, protecting and restoring critical forest habitat. Biological diversity in Central Appalachia is on the decline, yet overall forest cover is increasing. In response, ARC's three-phased Central Appalachian Assessment provides a platform for implementing wildlands restoration and rural economic revitalization in Appalachia. Portions of Phase One are presented here--specifically the assessment study area, ecoregions, rare, threatened and endangered species locations within the study area, and Roadless Opportunity Areas on the Monongahela National Forest.

EMAP's Approach to Managing Regional Data

Stephen S. Hale, John F. Paul, and Lawrence F. Rossner

U.S. Environmental Protection Agency, Atlantic Ecology Division
27 Tarzwell Drive, Narragansett, RI 02882, U.S.A.

Assessing the overall environmental health of a region invariably means using databases from various organizations. The traditional choice faced by data managers of projects on the scale of the Mid-Atlantic Integrated Assessment (MAIA) is whether to try to rigidly centralize, which is time-consuming, expensive, and ultimately wasteful for one-time projects, or to use existing decentralized databases with all their problems of disparate formats. The Environmental Monitoring and Assessment Program (EMAP) is using a hybrid approach that incorporates desirable features of both options and that can live on at reduced scale after the original, larger project finishes. The two cornerstones to EMAP's approach are (1) that original data are best managed, described, and maintained by the organizations that collect them; and (2) that the closer these organizations can move toward common standards, directories, and descriptions for their separate databases, the easier it will be to integrate these data. EMAP uses four tools: (1) an Inventory of Environmental Monitoring Programs, which contains information about current data-collecting activities; (2) a Data Directory, which describes data sets of potential interest and points to the locations of supplementary non-EMAP data and metadata; (3) a web site (<http://www.epa.gov/emap>), which contains the Directory plus EMAP's data and metadata; and (4) "analytical" databases, small-but-centralized comprehensive databases on restricted subjects that allow all researchers to access data that are fully consistent across an entire region. These principles and tools comprise a hybrid approach that meets modern challenges of data management and that can be sustained by the home regions.

Designing a Spatially Balanced, Random Site Selection Process for a Regional Scale Stream Survey in the Mid-Atlantic - The EMAP Pilot Study

Alan T. Herlihy¹, David P. Larsen², N. Scott Urquhart³, Barbara J. Rosenbaum⁴,
and Steven G. Paulsen²

¹Oregon State Univ., Department of Fisheries & Wildlife, 200 SW 35th Street, Corvallis, OR 97333

²U.S. EPA, 200 SW 35th Street, Corvallis, OR 97333

³Oregon State Univ., Department of Statistics, Corvallis, OR 97333

⁴OA Corp., 200 SW 35th Street, Corvallis, OR 97333

Sample surveys have been used with great effectiveness in a variety of fields to describe the characteristics of populations that are too numerous to census efficiently. Best known are surveys associated with political polls (e.g. Gallup polls). Although sample surveys have long been used in a variety of arenas, their use for characterizing water resources has been limited. In 1993, the U.S. EPA, as part of the Environmental Monitoring and Assessment Program (EMAP), initiated a sample survey of streams in the mid-Atlantic. One of the major objectives of the survey was to quantify ecological condition in wadeable streams across the region. To accomplish this goal, 615 stream sites were selected using a randomized, systematic sampling design. The design utilized the digitized stream network taken from 1:100,000 scale USGS topographic maps as the sample frame. Using a GIS, 1st through 3rd order (wadeable) stream segments in the frame were randomly laid out in a line and sampled at fixed intervals after a random start. A variable probability approach was used so that roughly equal numbers of 1st, 2nd, and 3rd order stream sites would appear in the sample. The sample design allows inference to the status of the entire 230,000 km of wadeable stream length in the mid-Atlantic study area from the sample data. Samples were successfully collected from 509 sites representing 80% or 185,000 km of the mapped stream length. The remaining 20% of the mapped length was unsampleable due to access denials (7%), inaccessibility (4%), lack of a stream channel (4%), or a dry stream bed (5%).

Summary of Ecological Data Collected during EMAP, REMAP, and TIME Stream Surveys in the Mid-Atlantic Region

Alan T. Herlihy², James M. Lazorchak¹, James H. Green³, Brian H. Hill¹,
Frank H. McCormick¹, and Donald J. Klemm¹

¹U.S. EPA, National Exposure Research Laboratory, 26 W Martin Luther King Dr., Cincinnati, OH 45268

²Oregon State Univ., Department of Fisheries & Wildlife, 200 SW 35th Street, Corvallis, OR 97333

³U.S. EPA, Region 3, 11th and Chapline St., Wheeling, WV 26003

The surface water component of the USEPA's Environmental Monitoring and Assessment Program (EMAP) began stream pilot activities in the mid-Appalachian region in 1992. EMAP research was conducted along with the Temporally Integrated Monitoring of Ecosystems (TIME) and EPA Region 3 Regional Environmental Monitoring and Assessment Program (REMAP) programs. The ecological data that were collected during these studies were: biological response indicators (fish, macroinvertebrate and periphyton assemblages), functional system indicators (sediment metabolism and respiration), chemical indicators (major cations and anions, acid-base chemistry, nutrients, total iron and manganese, turbidity and color), physical habitat assessment metrics and RBP Habitat data, contaminant indicators (fish tissue and sediment toxicity) and research protocols (fish biomarkers). Over the first 3 years of the study, 615 Wadeable stream sites were randomly selected for study throughout EPA Region III (DE, MD, VA, WV, PA) and the Catskill Mts. of New York. Samples were collected from 509 of these randomly chosen sites plus 68 hand-picked reference/test sites during an index period from April to July. These sites were sampled by crews of USEPA, U.S. Fish and Wildlife Service, state and U.S. EPA contract personnel in each of the operational units of the EMAP, REMAP, and TIME projects. In 1996 two index periods were sampled, the spring low flow index period (April - July) and a summer low flow period (July - September). In 1997 and 1998, the EMAP Surface Water Program extended the geographical coverage to the Mid-Atlantic Integrated Assessment (MAIA) study area, added an additional class of streams to be sampled (Large Rivers) and changed the index period to summer low flow, July - September. The MAIA study consisted of approximately 400 sites spread from southern New York to northern North Carolina. More sites were located in the Piedmont and Coastal Plain Ecoregions than were sampled in the previous EMAP and REMAP programs.

Riparian Forest Restoration: Stream Geomorphology and Ecological Implications

W. C. Hession, M. McBride, and T.E. Johnson

Patrick Center for Environmental Research, Academy of Natural Sciences
1900 Ben Franklin Parkway, Philadelphia, PA 19103

The restoration of riparian or streamside forests has become a major focus of watershed initiatives throughout the mid-Atlantic region of the United States. Many people view these riparian buffers as management tools to filter pollutants from adjacent sources of sediments and nutrients. However, we view riparian forests as integral components of the landscape that regulate the structure and function of stream ecosystems. We are currently conducting two integrated, multi-disciplinary research projects to evaluate the effects of riparian forest restoration on aquatic ecosystems. The first, part of the EPA/NSF Water and Watersheds Program, is based on the hypothesis that headwater riparian forests are primary regulators of stream geomorphology which in turn influences the structure and function of stream ecosystems. The second, part of the EPA-ORD Ecological Restoration Grant Program, focuses on how catchment conditions (i.e., urbanization) affect the success of riparian forest restoration efforts designed to improve water quality and stream health. Combined, these projects involve extensive geomorphic and ecological measurements on study reaches with forest, meadow, open, and restored riparian zones in more than 30 1st through 4th order streams in southeastern Pennsylvania and northeastern Maryland. We will present the geomorphologic measurements that suggest that forested streams are significantly different from streams bordered by meadows or mowed grasses. In addition, we will present preliminary data that suggests that: 1) this geomorphic difference influences aquatic ecosystem structure and function, and 2) the nature of riparian forests' beneficial influence on stream ecosystems is affected by catchment conditions.

Modeling Land-Use Change in MAIA

Laura E. Jackson

U.S. Environmental Protection Agency, Office of Research and Development
Research Triangle Park, NC 27711

The EPA Office of Research and Development (ORD) is addressing the question, “Where will projected land-use change most threaten ecological resources in the mid-Atlantic region?” Research is progressing within a multiple-scale framework to identify 1) county aggregations and 2) specific watersheds where projected growth and land-use conversion pose significant threats to sensitive ecological resources. A combination of region-wide modeling techniques is currently being pursued in-house and with the Departments of Agriculture and Interior. Synthesis of these results will identify multiple-county aggregations most likely to undergo significant land-use change. When overlaid with large-scale ecological resources of concern, these subregions will illustrate community risk management priorities for EPA Regions II, III, and IV. They will also provide the focus for more intensive research, serving as test areas for the application and integration of higher-resolution, spatially explicit models developed within ORD, EPA Program Offices, and the academic community. Collaborative application of these models under selected economic and policy scenarios will lead to local development profiles across a range of resolutions and certainty. ORD will use the detailed development profiles that emerge to drive exposure and effects models, arriving at ecological vulnerability profiles at the eight-digit watershed scale. Vulnerability profiles will include ecological resources directly displaced by land-use conversion, and those indirectly impacted by increased quantity and toxicity of runoff and air pollution.

Patterns of Breeding Bird Diversity and Landscapes in the United States Mid-Atlantic Region

K. Bruce Jones¹, Kurt H. Riitters², J.D. Wickham³, Anne C. Neale¹, and Robert V. O'Neill⁴

¹Environmental Protection Agency, Las Vegas, NV

²U.S. Geological Survey, Knoxville, TN

³U.S. Tennessee Valley Authority, Norris, TN

⁴Oak Ridge National Laboratory, Oak Ridge, TN

Changes in landscape composition and pattern have significant consequences for plants, animals, and entire biotic communities, primarily through alteration of the amount and spatial pattern of suitable habitat. Changes in suitable habitat influence landscape-level processes of plant and animal metapopulations, including immigration, emigration, and population sizes; these in turn influence species' vulnerabilities to (probabilities of) extinction. Broad-scale changes in landscape patterns across regions, including decline and fragmentation of natural land cover types, and increases in agricultural lands and urban environments, have resulted in declines in biological diversity, terrestrial productivity, water quality, and certain ecological services, such as resistance and resilience to catastrophic flooding.

Taking advantage of a new set of continuous landscape data of relatively fine scale (30 meters), and a 30-year database on breeding bird abundance and diversity, we evaluated relationships between breeding bird diversity and metrics of landscape pattern across the United States Mid-Atlantic Region. This paper reports results of this study and discusses the results within the context of regional-scale, landscape analysis.

Notice: *The U.S. Environmental Protection Agency, through its Office of Research and Development funded this research and approved the abstract as the basis for an oral presentation. The actual presentation has not been peer reviewed by EPA. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.*

Restored Riparian Buffers as Tools for Ecosystem Restoration in the MAIA; Processes, Endpoints, and Measures of Success for Water, Soil, Flora, and Fauna

Eric E. Jorgensen¹, Timothy J. Canfield¹, and Frederick W. Kutz²

¹National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Ada, OK 74820

²National Exposure Research Laboratory, U.S. Environmental Protection Agency, Annapolis, MD 21401

Riparian buffer restorations are used as management tools to produce favorable water quality impacts and the basis for riparian buffers as an instrument of water quality restoration rests on a relatively firm foundation. However, the extent to which buffers can restore riparian ecosystems; their functionality and species composition, are essentially unknown. In light of the foregoing, two broad areas of research are indicated. First, data are needed to document the relative effectiveness of riparian buffers that differ according to width, length, and plant species composition. These questions, of optimizing buffer dimension and species composition for functionality, are of central importance even when attenuation of nutrient and sediment loads alone are considered. Second, where ecosystem restoration is the goal, effects to in-stream and terrestrial riparian biota need to be considered. Relatedly, the effects of the restoration on the landscape need to be considered. Particularly, at what rate do the effects of the riparian buffer on in-stream water quality, biota, and habitat diminish downstream from restored sites? Answers to these important questions are needed, for streams and watersheds of different size and for areas of differing soil type within watersheds. USEPA-NRMRL has initiated a research project that will document the potential for buffers to restore riparian ecosystems; focusing on water quality effects but also, importantly, documenting effects on biota; particularly periphyton. The ultimate goal of research projects developed under this paradigm of ecosystem restoration is to develop data that are needed to implement riparian buffer restorations in the MAIA and elsewhere.

Terrestrial and Streamside Salamander Monitoring at Shenandoah National Park

Robin E. Jung, Sam W. Droege, and John R. Sauer

USGS Patuxent Wildlife Research Center, 12100 Beech Forest Rd., Laurel, MD 20708

In response to concerns about widespread amphibian declines and the need to evaluate and validate monitoring techniques for amphibians, a study testing amphibian monitoring techniques was initiated in the spring of 1998 in Shenandoah National Park. Fifteen salamander and ten anuran species are found in Shenandoah National Park, but testing focuses on salamanders because they are widespread and abundant throughout the Park. The goals of the program are to 1) evaluate bias and efficiency in several sampling methods for salamanders, and 2) assess spatial and temporal variation in salamander populations in relation to environmental variables. This work is conducted under the auspices of DISPro (Demonstration Intensive Site Project), an interagency effort of the EPA and NPS.

To evaluate bias and efficiency in sampling, research was conducted using a variety of population indexes and visibility-adjusted population estimation procedures. Population size of terrestrial salamanders was estimated from mark-recapture and area-constrained searches on the forest floor and under natural and artificial cover objects during the day and on wet nights. For stream and streamside salamanders, four monitoring methods (leaf litter bags, shoreline transect searches, 1 m² quadrat searches, and electroshocking) were used throughout the Park. To evaluate associations of salamanders and environmental variables, vegetation, soil pH and moisture, water quality, and other variables were measured at sampling sites. In conjunction with pilot data from other salamander monitoring efforts at the USGS Patuxent Wildlife Research Center and other sites, the monitoring results will be used to help establish park-wide long-term standardized monitoring programs for salamander species.

Maryland Biological Stream Survey: Application of Probability-Based Sampling to Watershed Assessment and Aquatic Resource Management

Paul F. Kazyak¹, Daniel M. Boward¹, Scott A. Stranko¹, Anthony P. Prochaska¹, Martin Hurd¹, Helen M. Dail, Ronald J. Klauda¹, Raymond P. Morgan II², Lenwood W. Hall, Jr.³, Mark Southerland⁴, and Nancy Roth⁴

¹Maryland Department of Natural Resources, 580 Taylor Ave., Annapolis, MD 21401

²University of Maryland CES, Appalachian Laboratory, 214 Gunter Hall, Frostburg, MD 21532

³University of Maryland Wye Res. and Ed. Center, PO Box 169, Queenstown, MD 21658

⁴Versar, Inc., 9200 Rumsey Rd., Columbia, MD 21045

During 1995-97, the Maryland Department of Natural Resources conducted a statewide survey of 1st through 3rd order non-tidal streams to assess ecological conditions. The goals of the survey were to characterize the current status of Maryland streams, provide a baseline inventory for future trend analysis, identify relationships between stressors and ecological condition, and aid in the targeting of restorations and protection activities. A probability-based, lattice sampling design stratified by river basin and stream order was used to select the 955 segments sampled. At each 75 m segment, fish, benthic macroinvertebrates, herpetofauna, water quality, and physical habitat were evaluated. Cluster analysis was performed on biological data to define natural community stratification. Non-biological, *a priori* criteria were applied to the dataset to establish reference conditions, and Indices of biotic integrity (IBIs) were tested and validated for fish and benthos and applied to identify healthy and degraded streams. On a statewide basis, fish assemblages indicate that 20%, 26%, 15% and 14% of stream miles were in good, fair, poor and very poor condition, respectively (25% of streams were not rated using the fish IBI because of small watershed size (<300 acres). Overall, benthic IBIs indicated a higher degree of impairment, with 11% good, 38% fair, 26% poor, and 25% of stream miles in very poor condition. Using an approach similar to that used for the fish and benthic IBIs, a provisional index of habitat quality was constructed and applied on a statewide scale. In addition to characterizations using ecological indices, quantitative estimates of fish populations were made. Approximately 61 million fish are found in Maryland streams, with just two species, blacknose dace and mottled sculpin, comprising 33% of the total. In contrast, 7 native stream species had populations less than 5000 individuals. Based on probable species distributions, brook trout and American eel, once dominant features of Maryland streams, have declined markedly due to widespread habitat loss. Conversely, few watersheds in Maryland did not contain introduced species. Analysis of landscape features and IBIs revealed a pronounced decline in fish communities in acid-sensitive watersheds as well as relationships between land cover, imperviousness, and IBIs. Using MBSS findings, more than 100 areas of the state have been targeted for protection and enhancement because they represent high quality or reference conditions. In addition, results of the survey were used as part of the Unified Watershed Assessment in support of the Clean Water Action Plan.

Providing Customized GIS Resources for Watershed-Based Citizen/Stakeholder Groups

Jacquelyn M. Rowe¹ and Paul J. Kinder, Jr.²

¹Natural Resources Analysis Center, West Virginia University, Morgantown, WV 26506-6108

²Canaan Valley Institute, P.O. Box 673, Davis, WV 26260

The Canaan Valley Institute (CVI) is a non-profit, non-advocacy organization serving communities of the Mid-Atlantic Highlands region. CVI works to aid communities in implementing locally-determined solutions to problems that threaten the economic or environmental resources of their watershed. The Institute is committed to improving the quality of life for the residents of the Mid-Atlantic Highlands by offering assistance to eligible groups interested in enhancing the economic and environmental sustainability of their communities. The assistance includes but is not limited to training workshops, technical expertise, monetary grants, and informational resources.

The Natural Resource Analysis Center (NRAC) at West Virginia University conducts a wide range of research activities centered in GIS, remote sensing, and natural resource policy and management. Current research and project areas include GIS-based decision support systems, application of spatial methods in economic policy analyses, vegetation and land cover mapping, watershed planning and restoration, wildlife habitat and distribution modeling, internet-based application development, and GIS software training.

Together, CVI and the NRAC are working to develop a set of customized GIS resources for use by watershed-based citizen and/or stakeholder groups across the Mid-Atlantic Highlands region. These GIS resources are being developed using a variety of spatial, non-spatial, and web-based products and formats, and are designed to meet varying levels of need and expertise by the watershed groups.

Introduction to the USEPA's Multimedia Integrated Modeling System

Joan H. Novak¹, Stephen R. Kraemer², John M. Johnston², Ann M. Pitchford³, and Greg P. Toth⁴

¹U.S. Environmental Protection Agency, National Exposure Research Laboratory MD-80, Research Triangle Park, NC 27711

²960 College Station Rd., Athens, GA 30605

³POB 93478, Las Vegas, NV 89193

⁴26 West Martin Luther King Dr., Cincinnati, OH 45268

The EPA's Office of Research and Development, under the initiative of the National Exposure Research Laboratory, is embarking on a long-term project to develop a Multimedia Integrated Modeling System (MIMS). The system will have capabilities to represent the transport and fate of nutrients and chemical stressors over multiple scales. MIMS will be designed to improve the environmental management community's ability to evaluate the impact of air quality and watershed management practices on stream and estuarine conditions. The system will provide a computer-based problem solving environment for testing our understanding of multimedia (atmosphere, land, water) environmental problems, such as the movement of chemicals through the hydrologic cycle, or the response of aquatic ecological systems to land-use change, with initial emphasis on the fish health endpoint. The design will attempt to combine the state-of-the art in computer science, system design, and numerical analysis (i.e. object oriented analysis and design, parallel processing, advanced numerical libraries including analytic elements) with the latest advancements in process level science (process chemistry, hydrology, atmospheric and ecological science). The problem solving environment will embrace the watershed/airshed approach to environmental management, and build upon the latest technologies for environmental monitoring and geographic representation. The MIMS team will promote a common and open development framework for the university and government modeling communities, and be open to partnerships with the private sectors when appropriate.

Overview of the Terrestrial Theme Session

Robert D. Mangold

USDA Forest Service, PO Box 96090, Washington, DC 20090

I will present an overview of the Terrestrial Theme Session. Many of the papers presented in this session stem from the close cooperation between the Environmental Protection Agency and the Forest Service. These two agencies, in collaboration with other agencies and Universities, have intensively studied the Mid-Atlantic, as part of the Mid-Atlantic Integrated Assessment (MAIA). The main impetus for this effort was the desire to produce a "State of the Forests" report for the MAIA region. The Report is being completed in phases. It is being done in a way that tests important components of the National Environmental Monitoring Initiative (NEMI), which is a framework developed in 1997 by a host of federal agencies outlining how agencies need to work together to improve the quality of their environmental assessments. The main theme of the NEMI framework is that assessments should be done across agency, across scale and across media. The papers in this session are efforts to show progress in the use of this important framework for making truly integrated assessments.

Assessment Framework for Mid-Atlantic Coastal Plain Streams Using Benthic Macroinvertebrates

J.R. Maxted¹, M.T. Barbour², J. Gerritsen², V. Poretti³, N. Primrose⁴, A. Silvia⁵, D. Penrose⁶,
and R. Renfrow⁷

¹DE Dept. of Natural Resources and Environmental Control, 29 S. State Street, Dover, DE 19901

²Tetra Tech, Inc., 10045 Red Run Boulevard, Suite 110, Owings Mills, MD 21117

³NJ Dept. of Environmental Protection, Bureau of Freshwater & Biological Monitoring, CN 427, Trenton, NJ 08625

⁴MD Dept. of Natural Resources, Tawes State Office Building (C-2), 580 Taylor Avenue, Annapolis, MD 21401

⁵VA Dept. of Environmental Quality, 5636 Southern Boulevard, Virginia Beach, VA 23462

⁶NC Dept. of Environment, Health, and Natural Resources, 4401 Reedy Creek Road, Raleigh, NC 27607-6445

⁷SC Dept. of Health and Environmental Control, 2600 Bull Street, Columbia, SC 29201

A collaborative study was completed among 6 states along the Mid-Atlantic seaboard of the U.S. A consistent approach was developed for collecting and interpreting macroinvertebrate data for low gradient nontidal coastal streams. The study had 3 objectives: (1) evaluate the validity of aggregating reference site data into a single region (i.e., “Bioregion”), (2) select biological metrics that best discriminate reference sites from sites impaired by habitat disturbance and organic pollution, and (3) develop an index that combines these metrics into an index of biological quality. Macroinvertebrate, physical habitat, and water quality data were collected in 106 streams during the Fall of 1995; 55 reference, 34 habitat stressed, and 17 water quality stressed sites were sampled. The classification of reference sites divided the coastal plain into 3 Bioregions separated north and south by the Chesapeake Bay and separated east and west by physiographic region (i.e., Ecoregion). Five metrics were found to be effective at discriminating impairment including the total number of taxa, number of EPT taxa, %Ephemeroptera abundance, the Hilsenhoff Biotic Index, and % clinger. An aggregated index, the Coastal Plain Macroinvertebrate Index (CPMI), developed using these metrics accurately assessed impaired sites 86% of the time. Reference sites in Bioregion 63S (the southern portion of Ecoregion 63) were highly variable and affected the discriminatory ability of the CPMI. This variability was likely due to the abundance of naturally acidic waters in the southern coastal plain and lack of long-term pH data.

The CPMI was equally accurate at assigning habitat and water quality impairment indicating a similar degree of ecological impact from these 2 stressors. Guidance is provided in applying the CPMI to other macroinvertebrate data sets in the region.

Assessing the Impacts of Forests on Human Welfare: Preliminary Results from the MAIA Forest Socioeconomic Assessment

D. Evan Mercer¹ and P.B. Aruna²

¹US Forest Service, Southern Research Station, 3041 Cornwallis Road, Research Triangle Park, NC 27709

²College of Forest Resources, North Carolina State University, Raleigh, NC 27695

The overall goal for socioeconomic component of the MAIA forest assessment is to develop systems for understanding and monitoring the relationship between changes in forest ecosystems and human well-being and quality of life in the MAIA region. During meetings with stakeholders in the region, 22 socioeconomic assessment questions were identified covering land use, resource (market and non-market) use, population demographics, investments in forest management, and forest policies. In the first phase of this effort, we are concentrating on assessing trends in forest resource use over the past two decades. In this paper, we present preliminary results from a subset of the 22 assessment questions. First, we present results of the analysis of changes in the distribution of human population and economic activities associated with forest resource dependent industries and tourism in the MAIA. Second, trends in wood products employment and income between 1975-1995 are used to examine the economic contributions of the forest based manufacturing sector in the Mid-Atlantic region. Finally, we examine the supplies of and demands for major types of forest recreation settings and activities within the MAIA region. We discuss the implications of these results for forest management and policy and suggest research for the second phase of the MAIA forest ecosystems assessment.

Using MAIA Information for Management Decisions and Informing the Nontechnical Public

Alvin R. Morris

USEPA, Office of Environmental Data, 3RA10, 1650 Arch St., Philadelphia, PA 19103-20201

The inherent complexity of even the best scientific data often detracts from its usefulness as a tool for selecting and championing policy. In the courtroom, meeting room, the Congress or the voting booth, the messages carried by scientific evidence are found effective only in proportion to the clear simplicity of how that message is conveyed.

Unfortunately, the cornerstone evidence used by the EPA to pursue environmental protection is often terribly complex. The need to interpret our intricate monitoring and research data into displays useful to the public debate has grown to a point where we need to find better ways to help the non-scientist better understand the messages the data can tell.

There are several messages which data-based information supports:

- documenting and illustrating EPA's messages;
- using environmental indicators to measure progress;
- selection of environmental priorities;
- helping the assessment of state PPA/PPG proposals;
- describing the impact of environmental action or inaction on people and/or living resources;
- provide data, information and tools to the public and communities so they can evaluate environmental information for their "neighborhoods" and make knowledgeable decisions.

The need for clearly expressed and easily understandable information expands further when one considers the growing variety of media choices available for carrying our message. Written press releases are now only the tip of the iceberg that includes TV, targeted video productions, web sites and related Internet linkages.

This discussion will offer some guidelines for visually presenting technical information to managerial and to non-technical audiences with some examples of each.

A Report on the Condition of the Mid-Atlantic Estuaries

John F. Paul, Charles J. Strobel, Brian D. Melzian, John A. Kiddon, James S. Latimer,
Donald J. Cobb, Daniel E. Campbell, and Barbara S. Brown

U.S. Environmental Protection Agency, Atlantic Ecology Division, 27 Tarzwell Drive, Narragansett, RI

For environmental management programs to be effective, decision-makers need to have an understanding of current environmental conditions as well as information on trends or changes that may be occurring over time. The report, Condition of Mid-Atlantic Estuaries, summarizes our current understanding of the ecological condition of estuaries in the Mid-Atlantic. Sources of information included program reports and databases produced by National Estuary Programs, Chesapeake Bay Program, state monitoring programs in Delaware, Maryland, and Virginia, and federal programs such as NOAA National Status & Trends Program, NOAA National Shellfish Register, USFWS National Wetlands Inventory, and EPA's Environmental Monitoring and Assessment Program. Information is presented on water quality (e.g., nutrient levels and dissolved oxygen concentrations), sediment contamination, and the condition of wetlands and living resources (e.g., benthos, fish, shellfish, and waterfowl). This information has been analyzed and summarized in a "report card" on ecological condition.

Major findings regarding specific problems include: the shellfish industry is one of the most impacted industries of the Mid-Atlantic states and is also one of the most severely threatened. The decline in oyster harvests has been precipitous, and is related to disease, overfishing, and pollution. The Delaware Estuary is highly impacted by lingering toxic contaminants associated with urbanization in the estuarine watershed and industrialization along the lower section of the Delaware River. Chesapeake Bay is the most hypoxic (very low dissolved oxygen concentrations) of estuaries in the region. The low levels of dissolved oxygen are primarily a result of nutrient overenrichment. The Delmarva coastal bays are moderately enriched, particularly in Delaware, largely from agricultural sources. Eutrophication is increasingly noticeable in dead end canals along developed shorelines. The coastal waters presently exhibit low levels of nutrients and chlorophyll; however, evidence suggests that these levels may be rising, indicating a potential for future environmental problems.

The Mid-Atlantic estuaries are being impacted to varying degrees. They are at risk and in need of active management to restore and maintain environmental quality and sustainable resources. The states, in conjunction with EPA through the Chesapeake Bay Program and the National Estuary Programs, have instituted environmental management programs to address these environmental concerns. The results of these environmental programs are becoming evident.

The Baltimore Ecosystem Study: A Long Term Ecological Study of a Metropolitan Area

Richard V. Pouyat

USDA Forest Service, c/o Baltimore Ecosystem Study, Technology Research Center, Rm 134, University of Maryland Baltimore County, Baltimore, MD 21228

Metropolitan areas are complex ecosystems that have hardly been examined from a rigorous ecological perspective. To develop approaches and methodologies to address this problem, the National Science Foundation funded for the first time two urban Long Term Ecological Research (LTER) Projects in 1997. The Baltimore Ecosystem Study (BES) was one of the two proposals selected for the entire U.S.A. This new and exciting LTER project will be funded for six years and if successful will be funded for additional six year periods so that long term data will be collected. As part of the research program, we will employ descriptive, historical and experimental analyses. We will characterize and monitor vegetation, soils, hydrologic and atmospheric processes, and socioeconomic dynamics. We will produce high resolution, whole-watershed and whole-city estimates of ecological and socioeconomic fluxes, as well as simulation models capable of depicting the interactive effects of land use, habitat and social change on ecological functions. Data from historical records and sediment pollen cores will allow us to test hypotheses about how social and ecological factors interact to affect how these functions have changed in the past and how they might change in the future. Both educational and technological transfer programs will be developed to ensure that data and knowledge gained from BES will be made available to the general public and government agencies.

An Assessment of Contaminant Trends and Data Gaps for Terrestrial Vertebrates Residing within Atlantic Coast Estuaries

Barnett A. Rattner¹, Jennifer L. Pearson², Nancy H. Golden², Jonathan B. Cohen ¹,
R. Michael Erwin¹, and Mary Ann Ottinger²

¹USGS, Patuxent Wildlife Research Center, Laurel, MD 20708

²Department of Animal and Avian Sciences, University of Maryland, College Park, MD 20742

The Biomonitoring of Environmental Status and Trends (BEST) program of the Department of the Interior is focused to identify and understand effects of contaminant stressors on biological resources under their stewardship. One BEST program activity involves evaluation of retrospective data to assess and predict the condition of biota in Atlantic coast estuaries. A “Contaminant Exposure and Effects--Terrestrial Vertebrates” database (CEE-TV) has been compiled through computerized literature searches of AGRICOLA, Aquatic Sciences and Fisheries Abstracts, BIOSIS, Fish and Wildlife Reviews, and TOXLINE, review of existing databases (e.g., US EPA Ecological Incident Information System, USGS Diagnostic and Epizootic Databases), and solicitation of unpublished reports from conservation agencies, private groups, and universities. Summary information has been entered into the CEE-TV database, including species, collection date (1965-present), site coordinates, sample matrix, contaminant concentrations, biomarker and bioindicator responses, and reference source, utilizing a 96-field dBase format. Currently, the CEE-TV database contains 3650 geo-referenced records representing 189 vertebrate species and >150,000 individuals residing in estuaries from Maine through Florida. This relational database can be directly queried, imported into the Geographic Information System to examine spatial tendencies, and used to identify “hot-spots”, generate hypotheses, and focus ecotoxicological assessments. An overview of temporal, phylogenetic, and geographic contaminant exposure and effects information, trends, and data gaps will be presented for terrestrial vertebrates residing in estuaries in the mid-Atlantic region of the United States.

The Regional Vulnerability Assessment Program

Elizabeth R. Smith, Rick A. Linthurst, and Jay J. Messer

U.S. Environmental Protection Agency, National Exposure Research Laboratory, MD-75,
Research Triangle Park, NC 27711

Regional vulnerability assessment (ReVA) can be defined as the assessment of the likelihood that stressors to ecosystems in a defined area will cause ecological processes and functions to vary beyond the range of natural variability, such that subsequent adverse effects could reduce that ecosystem's ability to provide the ecological goods and services that the public has come to expect and desire. It is comparative, in that it seeks to simultaneously include multiple stressors, multiple receptors, and multiple scales. The goal of ORD's ReVA research is to provide to decision-makers and stakeholders with a process to do an assessment of the current and anticipated regional ecosystem vulnerabilities, based on observed and predicted changes in exposures acting singly, and in combination. Accomplishing this goal will enable stakeholders to target limited resources at specific areas and problems where intervention, restoration, or protection is most critical and/or cost effective.

The Mid-Atlantic Region has been selected as the pilot location to develop, test, and document scientific approaches to ReVA. The initial focus of work has been to identify and characterize stressors within the region, and a preliminary product, *The Mid-Atlantic Stressor Profile Atlas*, will be released soon. The *Atlas* presents maps depicting acid deposition, coal mining, population growth, landscape patterns, agricultural nitrogen enrichment, tropospheric ozone concentrations, pesticide use, soil erosion, and UV-B irradiance. Future work will concentrate on 1) refining stressor profiles in terms of accuracy and inclusiveness, then doing future predictions; 2) characterizing receptors and developing exposure profiles for current and future scenarios; and 3) completing a comparative ecological risk assessment for the region by 2001.

Using Forest Inventory and Health Monitoring Data to Assess the Diversity, Productivity and Health of Trees in the Mid-Atlantic Region

James R. Steinman

USDA Forest Service, Northeastern Research Station, Radnor, PA 19087

The Forest Inventory and Analysis (FIA) and Forest Health Monitoring (FHM) programs of the USDA Forest Service manage an extensive network of field plots that are the best available sources of forest tree measurements in the mid-Atlantic region. This study utilized FIA data collected from 22,382 one-fifth acre plots to estimate the regional abundance and distribution of living trees and dead trees by species and size. FHM data collected from 193 one-sixth acre plots were also used to provide information pertaining to annual changes in health of trees as evident from crown conditions and stem/root damage. The collective analyses of these data were used to assess species diversity, productivity, regeneration, mortality, removals and current health of trees throughout the forest. Statistical results were summarized to depict stand- and landscape-level attributes by state and ecological subsection. Corresponding geo-referenced data sets were also created for eventual integration with information from other assessments. Analytical findings can be used by land managers to help: 1) evaluate the current status of forest health, 2) identify forest resource issues, 3) plan forest management goals, and 4) integrate other sources of information about natural resources in the mid-Atlantic region.

The Mid-Atlantic Highlands Assessment: Ecological Condition of Small Streams

John L. Stoddard¹, Steven G. Paulsen¹, David P. Larsen¹, Phil J. Kaufmann¹, Alan T. Herlihy²,
Kent Thornton³, Frank H. McCormick⁴, Don Klemm⁴, James M. Lazorchak⁴

¹U.S. EPA, Western Ecology Division, 200 SW 35th Street, Corvallis, OR, 97333

²Oregon State University, c/o U.S. EPA, 200 SW 35th Street, Corvallis, OR, 97333

³FTN Associates, 3 Innwood Circle, Suite 220, Little Rock, AR 72211

⁴U.S. EPA, Ecological Exposure Research Div., 26 West Martin Luther King Dr., Cincinnati, OH 45268

The Mid-Atlantic Highlands Assessment (MAHA) is a product of the Environmental Monitoring and Assessment Program (EMAP) surface waters component. Its goals are to describe the ecological condition of first through third order streams in the Highlands using biological assemblage data, to describe the relative risk to streams from major stressors in the region, and to “diagnose,” through associations, the likely causes of ecological impairment. In 1993 and 1994, just over 500 stream reaches, selected through a probability design, were sampled in the late spring. Each stream was sampled to describe its fish, benthic invertebrate and periphyton assemblages, fish tissue contamination, instream chemistry, and instream and riparian habitat measures. Using a fish Index of Biotic Integrity (IBI), the MAHA report finds that half (51%) of stream miles in the Highlands are in poor condition with respect to fish assemblages. The richness of sensitive invertebrate taxa (*Ephemeroptera*, *Plecoptera* and *Trichoptera*, or EPT) suggests that most stream miles are in good (53%) or marginal (30%) condition. The most common stressors are introduced fish species (34% of stream miles have non-native fish present), riparian habitat disturbance (24% of stream miles poor condition), instream habitat disturbance (17% in poor condition), mine drainage (14% of stream miles have mine drainage impacts), acidic deposition (10% affected), nutrient enrichment (5%).

Analysis of Forest Health in the MAIA Region

Kenneth W. Stolte¹, William H. Smith¹, and Casson Stallings²

¹USDA Forest Service, Southern Research Station, Research Triangle Park, North Carolina

²ManTech Environmental Corporation, Research Triangle Park, North Carolina

The Forest Health Monitoring (FHM) program is evaluating the health of the forests in the MAIA region, by developing a set of assessment issues for the forest, based on the ecological criteria and indicators detailed in Santiago Declaration. This report outlines the process for evaluation of forest health, and addresses two of the major criteria, productivity and vitality. To address these issues, we evaluated some of the major forest stressors and the spatial and temporal patterns in the condition of the forests. Spatial and temporal trends in forest condition were based on Forest Health Monitoring plot and survey data collected in 1991-1997, and analyzed by ecoregion sections. We found that the northern half of the MAIA is in a high wet deposition area for nitrate, sulfate, and hydrogen ion based on 1979-1995 NADP data. Lichen species diversity was low in these areas. Ozone exposure is high in MAIA, as is ozone injury to bioindicator species. Change in tree volume and carbon sequestration was low, and tree mortality high in one ecosection in MAIA. Transparency of tree crowns is increasing in some ecosections in MAIA, and damage to trees from multiple causes is increasing in some ecosections. The mortality risk to trees from gypsy moth is high throughout the MAIA region.

Using Resource Economics to Predict Land Use in the Mid-Atlantic Region

Ian W. Hardie,¹ Peter J. Parks,² Cheryl A. Tedder,² David N. Wear³

¹Department of Agricultural and Resource Economics, University of Maryland, College Park, MD 20742

²Department of Agricultural, Food, and Resource Economics, Cook College, Rutgers University, New Brunswick, NJ 08901-8520

³Economics of Forest Protection and Management, USDA Forest Service, Post Office Box 12254, Research Triangle Park, NC 27709

Demands for forest, farm, and developed land are evolving in the mid-Atlantic region. The demand for land in developed uses, as well as demands for various forest and farm products are changing in response to population growth, demographic shifts, and market forces. As demand factors change so do relative land values. Land area in future forest, farm, and developed uses may shift as landowners re-evaluate relative net benefits from land use alternatives.

This study examines the effects of various land demand and supply factors on the determination of land use patterns in the mid-Atlantic region. Driving variables include costs and benefits from various uses, per-capita income, farmland owner age, and measures of land quality. Model parameters are estimated using a generalized multinomial logit procedure. Results from the study are used to estimate proportions of area by land use category (forest, pasture, crop, and urban) on a county by county basis. Simulated landscapes under hypothetical future economic conditions are prepared and illustrated using geographic information system (GIS) techniques.

Forest-Stream Interactions within the Mid-Atlantic Region

Kent W. Thornton¹, Shannon P. Holbrook¹, Kenneth L. Stolte², and Ronald B. Landy³

¹FTN Associates, Ltd., 3 Innwood Circle, Ste 220, Little Rock, AR 72211

²Forest Health Monitoring, USDA Forest Service, Forest Sciences Laboratory, P.O. Box 12254, Research Triangle Park, NC 27709

³US Environmental Protection Agency, Region 3, 201 Defense Highway, Ste 200, Annapolis, MD 21401

Agricultural and urban land use activities have affected stream ecosystems throughout the Mid-Atlantic region. However, over 70% of the Mid-Atlantic region is forested. A study was conducted to investigate the effects of management practices on forested stream ecosystems throughout the Mid-Atlantic region. The study consisted of two phases: Phase 1 was a literature synthesis of information available on the effects of forest management practices on stream hydrology, erosion and sedimentation, riparian habitat alteration, chemical addition, and change in biotic diversity in the Mid-Atlantic region. In Phase 2, data from mid-Atlantic streams were analyzed to assess the effects of forest land use on stream quality at the regional scale.

Typically, it is the larger order streams in which monitoring and assessment occurs - 3rd order or higher streams. The impacts of forest management practices, particularly hydrologic modifications and riparian buffer zone alteration, occur predominantly in first and second order streams with cumulative impacts translating to higher order streams. Nutrient increases from forest management practices are generally small, but pesticide additions are more prevalent. A series of conceptual models have been developed to depict the interaction among forested land use and stream quality in the Mid-Atlantic. These conceptual models will be presented to explain the regional estimates of stream quality throughout the Mid-Atlantic Highlands.

Change in the Acid-Base Status of Streams Associated with Forested Mountain Watersheds in the Mid-Appalachian Region

James R. Webb, Frank A. Deviney, Jr., Bernard J. Cosby, and James N. Galloway

Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903

The mid-Appalachian region is one of the areas of the United States most affected by acidic deposition. Many of the upland streams in the mid-Appalachian region are especially susceptible to acidification due to high rates of acidic deposition, the presence of watersheds with base-poor bedrock, and the delayed-response properties of regional soils. The Shenandoah Watershed Study and the Virginia Trout Stream Sensitivity Study have provided a quarterly record of stream water composition for 64 streams associated with forested mountain watersheds in the western Virginia region. Classification by watershed bedrock type explains variation in current acid-base status of the sampled streams. Among streams in the Blue Ridge Mountain province, the median acid-neutralization capacity is 3.4 $\mu\text{eq/L}$ for streams associated with siliciclastic bedrock, 59.8 $\mu\text{eq/L}$ for streams associated with granitic bedrock, and 161.3 $\mu\text{eq/L}$ for streams associated with basaltic bedrock. Among streams in the Ridge and Valley province, the median acid-neutralization capacity is 0.6 $\mu\text{eq/L}$ for streams associated with siliciclastic bedrock, 23.6 $\mu\text{eq/L}$ for streams associated with minor carbonate bedrock, and 167 $\mu\text{eq/L}$ for streams associated with carbonate bedrock. More than 50% of the streams in western Virginia that support reproducing populations of the native brook trout (*salvelinus fontinalis*) drain siliciclastic watersheds. The acid-base status of these streams reflects an unfavorable balance between sulfate from atmospheric sources and base cations from watershed sources. An analysis of change in the acid-base status of these streams must account for change in atmospheric deposition and for variation related to discharge and forest disturbance.

Forest Fragmentation as an Economic Indicator

James D. Wickham¹, Robert V. O'Neill², K. Bruce Jones³

¹U.S. Environmental Protection Agency, Research Triangle Park, NC 27711

²Oak Ridge National Laboratory, Oak Ridge, TN 37831

³U.S. Environmental Protection Agency, Las Vegas, NV 89119

There is concern over the ecological consequences of habitat fragmentation because of the pace and magnitude of conversion of land from natural cover to anthropogenic uses. Nevertheless, there are few studies that show a quantitative relationship between fragmentation and economic factors. For the southside economic region of Virginia, we show that forest fragmentation is positively correlated with a simulated surface of demand for land and per-capita tax proceeds from property. We also show that land-cover change over a 20 year period increased as simulated demand for land increased. The correspondence between land-cover change and demand for land suggests that forest fragmentation will occur at a greater rate in the eastern portion of the southside economic region in the future.

Maryland's Integrated Natural Resources Assessment (INRA)

John C. Wolf

Maryland Department of Natural Resources, 580 Taylor Ave., Annapolis, MD 21401

Over the past two years Maryland has been developing a statewide assessment that provides an ecosystem-based framework for public and private decisions affecting natural resource management in Maryland. Drawing on many of the components of MAIA, Maryland's Integrated Natural Resources Assessment (INRA) is providing the Department of Natural Resources and interested partners with short and long term benefits including: (1) a conservation and restoration targeting strategy based on ecological priorities as well as impending threats; (2) a comprehensive framework for cooperative action within and outside of DNR; and (3) an ecosystem-based strategy for protecting the resource base associated with much of Maryland's economy.

INRA utilizes GIS and related information to characterize watershed and other landscape units based on ecological and socioeconomic condition and stress information derived from a variety of sources. This information is then interpreted and applied based on agency programmatic goals and objectives.

The assessment tool has matured to the point that it is now being used for conservation and restoration targeting applications at multiple spatial scales. This presentation will summarize the current status of INRA and focus on its use in Maryland's Clean Water Action Plan and in the evaluation of a statewide greenways systems.

II. Posters

CIMS - A Regional System for Integrating Chesapeake Bay Information

Lowell H. Bahner, 410 Severn Avenue, Suite 107, Annapolis, MD 21403
Anthony V. Allred, Jr., DNR, 580 Taylor Ave., Annapolis, MD 21401

The Chesapeake Information Management System (CIMS) is an initiative to organize the vast information resources in the Chesapeake Bay region. In 1996, the Chesapeake Bay Executive Council signed the "Strategy for Increasing Basin-wide Public Access to Chesapeake Bay Information". This document directs the Chesapeake Bay Program to develop and maintain a coordinated data management system, which provides timely information on the progress of the restoration program, and promotes greater understanding among citizens about the Bay, its problems, and about policies and programs designed to help it. The Strategy directs the implementation of CIMS as a user-friendly basin-wide system designed as a distributed network among participating organizations throughout the watershed. Participating organizations become partners in CIMS by initiating a Memorandum of Agreement and they become information providers by publishing their information over the Internet following accepted policies and guidelines.

The Chesapeake Bay Program sponsors the development and implementation of CIMS, by providing hardware, software, telecommunications, policies and guidelines, database designs, data dictionaries, metadata tools, metadata search engines, training, and web sites (<http://chesapeakebay.net/>). The priorities for CIMS implementation include: improved access to information; better documentation (metadata); up-to-date information; better tools for analyzing and interpreting information; integration of different types of information (water, air, land, biological), streamlined data processing and loading; and spatial (geographic) information.

Maryland DNR, a CIMS Partner Organization, is committed to participation in the Chesapeake Information Management System including the management and publication of a number of databases under CIMS. These databases, which will be mirrored to a world wide web server, include water quality, living resources, and toxics information. The water quality database is comprised of 57 relational tables. Additional living resource and toxics information will be added/linked to this database. This design permits DNR to work cooperatively with the other Chesapeake Bay Program agencies and partners to implement CIMS. DNR, assisted by staff from the University of Maryland Baltimore County are developing the Graphical User Interface (including the geographical interface) which provides interactive access to the Maryland environmental monitoring data.

The MAIA Estuaries Database- Design and Implementation

Henry W. Buffum², Stephen S. Hale¹, John F. Paul¹

¹U.S. EPA Atlantic Ecology Division, 27 Tarzwell Dr., Narragansett, RI 02882

²OAO Corporation, 27 Tarzwell Dr., Narragansett, RI 02882

The Mid-Atlantic Integrated Assessment (MAIA) Estuaries data management team is charged with maintaining a database of core measurements collected by the MAIA Estuaries collaborators. Since these data are collected and processed by several organizations, they need to be stored in a consistent and accessible format that can be used by all MAIA collaborators. To this end, a data base design that includes SAS datasets and ASCII data files has been implemented. Sediment toxicity, grain size, sediment and fish tissue chemistry, water quality, nutrients, and fish community data are stored in SAS datasets. Water column profiles, providing multiple readings of water quality parameters at different depths, are stored in ASCII files. Key fields allow all data to be linked to sampling station and visit information. The database currently contains data from the summer of 1997. Data from 1998 are being processed, reviewed and summarized for inclusion.

Using GIS for Watershed Analysis in the MAIA Region

Jane L. Copeland¹, George Morrison¹, John F. Paul²

OAQ Corporation, 27 Tarzall Drive, Narragansett, RI 02882

During the 1997 field season, approximately 125 estuaries in the MAIA region were sampled. The MAIA Assessment Team is looking at relationships between data collected in these estuaries and landscape indicators in the associated watersheds. In the past, watershed analyses in the MAIA region were done using the USGS 8-digit hydrologic unit codes (HMCS). The HUCS are useful for analyses involving watersheds of large estuarine areas. However, many of the estuaries sampled in 1997 are small areas and there is not a one-to-one relationship with the HMCS. Therefore, using GIS, watersheds were delineated for each sampled estuary. This poster will demonstrate the process used for the watershed delineation and will give examples of indices that might be explored by the Assessment Team.

Efficacy of Forest Health Monitoring (FHM) Indicators to Evince Impacts in a Chemically Manipulated Watershed

Janet D. Eckhoff¹ and G. Bruce Wiersma²

¹Department of Forest Ecosystem Science, University of Maine, 5755 Nutting Hall, Orono, ME 04469-5755

²Maine Agricultural & Forest Exp. Station, University of Maine, 5782 Winslow Hall, Orono, ME 04469-5782

Forest ecosystems around the world are undergoing a variety of changes as a result of various uses and impacts. To assess the status of forests across the United States and to monitor trends within those forest ecosystems, the U.S. EPA and U.S. Forest Service jointly established the Forest Health Monitoring (FHM) Program. This program identified and developed monitoring indicators which were implemented, in the early 1990's, on several sites across the U.S.A. The FHM indicators, including mensuration, crown condition, damage & catastrophic mortality, lichens, and vegetation structure, were not field tested under "controlled" conditions prior to their implementation. These FHM indicators and two additional indicators, canopy gap analysis and tree seed production, are now being tested at Bear Brooks Watershed Research Site in Maine (BBWM) for their ability to detect the impacts of pollutants, such as atmospheric deposition, on forest ecosystems. BBWM is a paired watershed study site. Since November 1989, West Bear Brook catchment has been chemically manipulated with bimonthly $(\text{NH}_4)_2\text{SO}_4$ applications. East Bear Brook catchment serves as a reference. The FHM design employs a cluster plot with four 0.1-ha (1/4-ac) fixed-radius (17.65-m or 58.9') macroplots in a triangular design covering a total of 0.4-ha (1-ac). This presentation will describe all the indicators being tested and present preliminary results from the mensuration, damage & mortality, and lichen indicators. Lichen indicator analysis has revealed the first known finding of the lichen *Parmelia fertilis* M11. Arg. anywhere in the U.S.A. and the second known finding of two other lichen species.

Perspective on Analysis and Research Integration Through the Baltimore-Washington Regional Collaboratory

Timothy W. Foresman

Director, Spatial Analysis Lab - University of Maryland, Baltimore County (UMBC)
Assistant Professor - Department of Geography and Environmental Systems
1000 Hilltop Circle, Baltimore, MD 21250

An experiment was initiated by the Spatial Analysis Laboratory of the University of Maryland, Baltimore County, in 1995 to determine the structural feasibility and potential applications for a regional spatial data management network. This spatial network, the Baltimore-Washington Regional Collaboratory, sponsored in part by NASA's office of Earth Science, has supported a series of outreach, education partnerships, and research activities dealing with ecological, social, and physical science issues. A hallmark program of the Collaboratory has been the 200-year land use dynamics study conducted in cooperation with the United States Geological Survey (USGS) HILT program. Direct results of the Collaboratory include the NSF funded Baltimore Ecosystem Study (Long-Term Ecological Research) in cooperation with the United States Forest Service (USFS), USGS, and EPA; and the Urban-Rural Index in cooperation with the Chesapeake Bay office. A complex stratification of regional data and users has been identified and linked to the Collaboratory. Results are presented in terms of the Web-based regional structure (systems and data architecture), and performance of the myriad outreach (regional community utilization), and research projects (data integration and synthesis).

URL: www.umbc.edu/bwrdc - Baltimore Washington Regional Collaboratory
baltimore.umbc.edu/lter - LTER

System EIGHT®: An Interactive Process to Evaluate Qualitative and Quantitative Environmental Indicators

Thomas C. Gulbransen¹ and Mark Curran²

¹Battelle, 110 Lake Ave South, Suite 35, Nesconset, NY 11767

²Battelle, 397 Washington St, Duxbury, MA 02332

MAIA and its partners need to integrate results from existing monitoring and research programs to assess the condition of ecological resources and to identify mitigation priorities. Data integration depends on investigators identifying comparable data types and defensible indicators. As these diverse data types are selected, it is essential they be viewed and compared together in an interactive manner. System EIGHT is an interactive process where scientists and managers use fuzzy logic to mimic their priorities and to project alternative decision scenarios. System EIGHT is an acronym for Environmental Indicators Graphical Heuristics Tool.

This project examines the utility of applying fuzzy logic decision support to the MAIA program. Three aspects of the System EIGHT process are under study: (1) ability to affect mitigation planning, (2) availability of defensible, pertinent data for integration, and (3) responsiveness of tool functions. The process' ability to affect planning relies on stakeholder participation in selecting proper questions and defining meaningful thresholds. Data availability is a function of scale selection, comparability amongst similar data types and relative importance of disparate environmental indicators. System EIGHT functions being examined include qualitative similarity comparisons (eg species sensitivity), quantitative sensitivity (absolute criteria or numeric ranges), relative importance weighting and interactive spatial displays.

Stakeholders involved in this study include regional and national EPA ORD staff, state agency representatives, local authorities and consultants. Additional participants are welcome. This preliminary assessment will be summarized in a report from the MAIA program.

Assessment of Sediment Toxicity in Delaware Bay and Adjacent Areas

Michelle R. Harmon and M. Jawed Hameedi

National Oceanic and Atmospheric Administration, 1305 East West Highway, Silver Spring, MD 20910

NOAA's National Status and Trends Program estimates the spatial extent of coastal environmental degradation due to contamination by toxic chemicals, using a series of regional studies as a basis for integration on a national scale. As part of the program, sediment toxicity in Delaware Bay was studied in September and October 1997. Preliminary data show that, among the toxicity tests used, the Microtox response was pervasive throughout the study area. Three sites in Delaware River and one in Delaware Bay were toxic based on the amphipod survival test and an additional seven sites, scattered throughout the study area, were toxic based on the sea urchin fertilization test. The Reporter Gene System (RGS) bioassay results for 13 sites were above the value associated with impaired benthic community structure. Numerous stations throughout the Bay exceeded ER-L sediment quality guidelines for both trace metals and organic compounds but only a few of the 81 sites exceeded an ER-M sediment quality guideline. By far the most abundant benthic taxonomic groups were Polychaeta, Oligochaeta, and Malacostraca, followed distantly by Bivalvia, Gastropoda, and Insecta. The highest mean macroinfaunal density was found in Maurice River Cove. Analyses of data continues, including distribution patterns among sediment toxicity, benthic fauna, and levels of contaminants in sediment.

The EMAP Web Site

Melissa M. Hughes², Stephen S. Hale¹, John F. Paul¹, Scott R. McAskill², David R. Bender²,
Nancy J. Cunningham², Thomas R. Richter² and Jane L. Copeland²

¹U.S. EPA Atlantic Ecology Division

²OAO Corporation, 27 Tarzwell Dr., Narragansett, RI 02882

The Environmental Monitoring and Assessment Program (EMAP) web site (<http://www.epa.gov/emap>) is the primary means of dissemination of EMAP information to all user groups. Four principal sections of the web site divide the information into descriptive, technical and scientific information from and about EMAP. Under Components and Contacts, the EMAP Working Groups and Regional EMAP (R-EMAP) Programs are described and Contact personnel listed, respectively. A link to the Mid-Atlantic Integrated Assessment (MAIA) web site is located here. Data set descriptions (Directory), scientific data and Catalog (metadata) files for EMAP, R-EMAP and related programs are available in standard formats under the Data link. The Data Directory is a searchable Oracle database that tracks these data sets and contains sufficient information for a user to locate data sets of interest. Most of the data sets listed in the Directory are in the possession of EMAP and are accessible on the EMAP WWW site. Associated with each ASCII data set is a metadata file which provides the user with information about methods, assumptions and data quality. Under Documents, standard Laboratory and Field Methods Manuals are provided to view and download, as are Statistical Summaries based on the data collected. In addition, a bibliography of EMAP documents can be searched.

An Interactive, Spatial Inventory of Environmental Data in MAIA

Laura E. Jackson¹ and M. Patricia Gant²

¹U.S. Environmental Protection Agency, Office of Research and Development, Research Triangle Park, NC 27711

²U.S. Environmental Protection Agency, Office of Research and Development, Annapolis, MD 21401.

The U.S. Environmental Protection Agency (EPA) has produced an interactive, spatial inventory of environmental data in MAIA that is now accessible on-line. The inventory includes maps of sampling locations, lists of measurements, and design information for 130 federal research sites and monitoring programs. It also features user-defined queries, resulting in a list of programs that satisfy search criteria (e.g., “Display the probability-based surveys that measure dry deposition and nutrient availability in soils.”), and are hot-linked to maps and other program information. The inventory was designed to facilitate an interagency pilot study, instigated by the National Science and Technology Council’s Committee on the Environment and Natural Resources, to integrate federal environmental monitoring and research activities. The inventory also provides information for the Mid-Atlantic Integrated Assessment (MAIA), led by EPA Region III and the Office of Research and Development. In addition, the inventory includes information to identify suitable field data for assessing the accuracy of satellite imagery. In each of these three applications, the inventory will be tested and evaluated as a potential prototype for completing additional regions of the U.S. Maintained as an Oracle database, the inventory is accessible on the internet at <http://www.epa.gov/monitor/>. Plans are underway to expand the MAIA inventory to include state, local and private environmental data collection activities as well.

Development of a Multi-Metric Biological Index Using Integrated State and EMAP Stream Monitoring Data

Benjamin K. Jessup and Jeroen Gerritsen

Tetra Tech, Inc., 10045 Red Run Blvd., Suite 110, Owings Mills, MD 20912

Biological monitoring data produced by EMAP and state programs throughout the MAIA region are plentiful, though not readily comparable. Fish and benthic macroinvertebrate data were obtained from EMAP, Pennsylvania, Maryland, and Delaware. Because the benthic macroinvertebrate data were more universally available, the assessment focused only on the one assemblage. Comparability of data was determined by examining both field collection methods and data distributions within two site strata, the Coastal Plain and the Non-Coastal Plain. The challenge of assessing biological integrity using the disparate data sets was met by standardizing the metrics within each monitoring program on a universal metric scoring scale based on a percentage of the 95th percentile of the data. Five metrics were common to all programs (total taxa, EPT taxa, % EPT, HBI, and % dominant taxon). The standardized metric scores were averaged and this final index score was used to determine the biological integrity of a site. The geographic distribution of sample sites was such that four major basins could be assessed; 1. the Allegheny, Monongahela and Upper Ohio, 2. The Chowan Roanoke and Lower Chesapeake, 3. The Delaware and Susquehanna, and 4. the Kanawha, Big Sandy and Upper Tennessee. Within each of these basins, site assessments were weighted according to program sampling design and final basin assessments were computed as percentages of good, fair or poor stream miles.

Potomac Watershed Studies: Tidal Freshwater Ecosystems and Stream Macroinvertebrates

R. Christian Jones

Department of Biology, MSN 3E1, George Mason University, Fairfax, VA 22030

For the past eighteen years the Freshwater Ecology Lab at George Mason University has studied the distribution of aquatic communities in selected portions of the Potomac River watershed. The longest running and most extensive work has involved a vertically integrated study of the Gunston Cove embayment on the tidal freshwater Potomac. Since 1983 water quality and plankton, benthos, and fish communities have been measured at a biweekly to monthly basis at several sites representing a shallow embayment and nearby river mainstem. Long-term trends in phytoplankton chlorophyll a in the shallow embayment indicate a decline in phytoplankton abundance which seems to be a lagged response to phosphorus controls adopted in the early 1980's. Phytoplankton chlorophyll a in the river failed to show this response. Another major project of the GMU Freshwater Ecology Lab is the effect of watershed land use on stream macroinvertebrate communities in the Virginia piedmont. Land use effects which have been examined are urban and suburban development and cattle grazing. Both of these land uses have been shown to lead to lower biotic integrity of stream macroinvertebrate communities. Management practices examined to date have had limited efficacy in restoring the integrity of the stream communities.

Providing Customized GIS Resources for Watershed-Based Citizen/Stakeholder Groups

Jacquelyn M. Rowe¹ and Paul J. Kinder, Jr.²

¹Natural Resources Analysis Center, West Virginia University, Morgantown, WV 26506-6108

²Canaan Valley Institute, P.O. Box 673, Davis, WV 26260

The Canaan Valley Institute (CVI) is a non-profit, non-advocacy organization serving communities of the Mid-Atlantic Highlands region. CVI works to aid communities in implementing locally-determined solutions to problems that threaten the economic or environmental resources of their watershed. The Institute is committed to improving the quality of life for the residents of the Mid-Atlantic Highlands by offering assistance to eligible groups interested in enhancing the economic and environmental sustainability of their communities. The assistance includes but is not limited to training workshops, technical expertise, monetary grants, and informational resources.

The Natural Resource Analysis Center (NRAC) at West Virginia University conducts a wide range of research activities centered in GIS, remote sensing, and natural resource policy and management. Current research and project areas include GIS-based decision support systems, application of spatial methods in economic policy analyses, vegetation and land cover mapping, watershed planning and restoration, wildlife habitat and distribution modeling, internet-based application development, and GIS software training.

Together, CVI and the NRAC are working to develop a set of customized GIS resources for use by watershed-based citizen and/or stakeholder groups across the Mid-Atlantic Highlands region. These GIS resources are being developed using a variety of spatial, non-spatial, and web-based products and formats, and are designed to meet varying levels of need and expertise by the watershed groups.

The MAIA Program Web Site

Patricia Gant¹, Sumner Crosby², Jeff Rosen³ and Daniel Martin³

¹U.S. Environmental Protection Agency, Office of Research and Development, Annapolis, MD 21401

²U.S. Environmental Protection Agency, Region 3, Philadelphia, PA 19103

³TPMC, Mill Wharf Plaza, Scituate, MA 02066

A prototype web site was built to help MAIA partners access the MAIA Information Management System. The system requirements and preliminary design phase are now underway and led by a regional data team. One goal of the system is to act as a central clearinghouse to enhance access to all MAIA projects and resources from raw data to final reports. The five main elements to the system that will be published on the web site include, links to MAIA partners; links to national and regional data warehouses; spatial data including maps, aerial photographs and satellite imagery; conventional and spatial digital library catalogs and inventories; and published reports, papers and technical references. The web site is also designed to provide access using common subject categories, such as Landscape, Streams, Forests and Estuaries. The web site will utilize server applications such as the ISITE/Z39.50 protocol for multi-library searching of FGDC compliant metadata records, and other federally recognized open designed applications to provide web based viewing and distribution of tabular and spatial data from very large databases. The prototype is under development and is available at <http://www.tpmcscituate.com/maia/>. The site will be moved to a regional EPA office when the first major release is complete.

Assessing the Accuracy of Land Cover and Landscape Indicators in Region III

Nancy E. Roth¹, Donal E. Streel¹, Frederick W. Kutz², James D. Wickham³, and K. Bruce Jones⁴

¹Versar, Inc., 9200 Rumsey Road, Columbia, MD 21045

²U.S. EPA, 201 Defense Hwy., Suite 200, Annapolis, MD 21401

³U.S. EPA, Mailstop MD-77B, Research Triangle Park, NC 27711

⁴U.S. EPA, P.O. Box 93478, Las Vegas, NV 89193-3478

Through the Multi-Resolution Land Characteristics (MRLC) Consortium, EPA and other federal agencies have cooperated in developing a land-cover data base for the United States. As part of this effort, EPA and Versar are assessing the accuracy of MRLC land cover data and landscape indicators in EPA Region III. The MRLC dataset is already viewed by EPA, states, and local agencies as an important tool for a variety of needs. Region III Mid-Atlantic Integrated Assessment recently developed indicators of landscape condition (based on MRLC data) to assess watersheds regionwide. Moreover, this accuracy assessment project will develop an approach to be implemented across the conterminous United States to complement ongoing land classification efforts. A regionwide assessment will be conducted through quantitative cross-checks of MRLC and derived indicators with high resolution aerial photography, primarily from the National Aerial Photography Program (NAPP). Activities underway include coordination with USGS and other agencies and development of the sampling design to assess data accuracy. Design criteria will reflect accuracy requirements important to data users and will address accuracy both regionwide and within specific land cover classes. Further investigations will consider issues affecting accuracy of special interest classes and the scale-dependence of accuracy. A final component will assess the accuracy of selected landscape indicators. This accuracy testing will help to ensure that high quality environmental assessments relying on land cover data and indicators can be performed at regional, state, and watershed scales.

Spatial Variability of Selected Ecological Indicators in Small Estuaries of the U.S. Mid-Atlantic Coast

Charles J. Strobel¹, John F. Paul¹, Melissa M. Hughes², Henry W. Buffum², Barbara S. Brown¹, and J. Kevin Summers³

¹U.S. EPA, 27 Tarzwell Drive, Narragansett, RI 02882

²OAO Corporation, 27 Tarzwell Drive, Narragansett, RI 02882

³U.S. EPA, Sabine Island, Gulf Breeze, FL 32561

In the early 1990s, EPA's Environmental Monitoring and Assessment Program (EMAP) collected data on the ecological condition of the estuaries of the Mid-Atlantic coast of the United States. This program was designed to evaluate the condition of the overall *population* of small estuaries (*i.e.*, those with a surface area $< 100\text{km}^2$), not to provide information on the condition of *individual* small estuaries. To address the needs of environmental managers, EMAP conducted a study in the summer of 1997 to provide information on individual small estuaries, as well as the overall population of estuaries. This consisted of an evaluation of the spatial variability of ecological indicators within these systems. One hundred and thirty nine probability-based sites in 11 estuaries were sampled for a variety of water quality and sediment parameters, including dissolved oxygen (DO), nutrient concentrations, and sediment grain size. Between eight and 29 stations per estuary were sampled. From this information we determined ecological condition (*e.g.*, percent area with a DO concentration $< 5\text{mg L}^{-1}$) for each estuary based on the total number of samples (N) collected in that estuary. We then recalculated this based on random samples sizes (n) from 1 to N and calculated the 90% confidence interval for each estimate. The confidence intervals were plotted against n to determine where the curve flattened. Results indicate that five stations provides sufficient information to characterize the water quality of most small estuaries. From the perspective of implementing a geographically broad monitoring program, monitoring of five stations per estuary represents a reasonable effort.

Assessing Effects of Natural and Anthropogenic Stressors in the Potomac Estuary

Henry A. Walker, James S. Latimer, and Edward H. Dettmann.

U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory,
Atlantic Ecology Division, 27 Tarzwell Drive, Narragansett, RI 02882

Ecological conditions in the Potomac Estuary are affected by a variety of natural and anthropogenic stressors. Variability in climate and anthropogenic activities affect fluxes of material through the watershed and cause variations in ecological conditions in the Potomac Estuary. A basic premise of this study is that conditions in the estuary and its watershed reflect the combined effects of natural and anthropogenic stressors, and that the effects of these anthropogenic and natural stressors can be distinguished. The investigation that we are initiating will involve: 1) analysis of existing data from the past 20 - 100 years using time series methods, 2) new measurements on sediment cores from the Potomac estuary, and 3) retrospective modeling approaches to link the response of water quality to changes in stressors. Estuarine effects to be considered include changes in the distribution and abundance of chlorophyll *a*, diatoms, dinoflagellates, ostracods, submerged aquatic vegetation, benthic fauna, dissolved oxygen, and foraminifera. Since current conditions may be due to the accumulation of effects over many years, our research will consider variability and changes during the past century in the context of long-term changes during the past 500 years. The availability of large data sets from the past century, long-term information on variability in precipitation from tree ring data from the past 300 years, and paleoecological studies by other investigators in the Potomac Estuary and main stem of Chesapeake Bay make the Potomac Estuary an ideal place to refine our methods for distinguishing estuarine effects of natural and anthropogenic stressors.

Establishing Watershed Conservation and Restoration Priorities Using Maryland's Integrated Natural Resources Assessment

Helen Stewart, Mary Searing, and John Wolf

Maryland Department of Natural Resources, 580 Taylor Ave., Annapolis, MD 21401

In an effort to take a more holistic, ecosystem-based approach to natural resources management issues facing the State, the Maryland Department of Natural Resources has developed a statewide, landscape level assessment framework utilizing environmental indicators at watershed scales. The resulting watershed assessment tool is one component of Maryland's Integrated Natural Resources Assessment (INRA), a statewide environmental assessment project that draws upon many of the landscape assessment techniques developed as part of MAIA.

The watershed assessment and prioritization components of INRA make use of a series of environmental indicators depicting ecosystem condition, landscape stresses and agency programmatic response capabilities for each of Maryland's 138 watershed analysis units. A GIS-based software tool - the Integrated Watershed Analysis and Management System (IWAMS) - has been developed to catalog, manipulate, combine, and weight the indicators based on user-defined decision rules. These decision rules are then applied in a comparative framework to identify those watersheds with relatively higher potential for ecosystem conservation and restoration activities.

Most recently, INRA has been used for the Unified Watershed Assessment required by the Clean Water Action Plan (CWAP). A series of watershed indicators for clean water, water quality, aquatic living resources, and landscape conditions were selected to identify watersheds in need of restoration (Category 1 watersheds) and those with pristine or sensitive conditions (Category 3 watersheds). INRA also provided the analytical framework for establishing watershed restoration priorities as required by CWAP. The results of applying INRA for CWAP were presented to the public at a series of meetings in September, 1998.

Maryland's Integrated Natural Resources Assessment (INRA)

John C. Wolf

Maryland Department of Natural Resources, 580 Taylor Ave., Annapolis, MD 21401

Over the past two years Maryland has been developing a statewide assessment that provides an ecosystem-based framework for public and private decisions affecting natural resource management in Maryland. Drawing on many of the components of MAIA, Maryland's Integrated Natural Resources Assessment (INRA) is providing the Department of Natural Resources and interested partners with short and long term benefits including: (1) a conservation and restoration targeting strategy based on ecological priorities as well as impending threats; (2) a comprehensive framework for cooperative action within and outside of DNR; and (3) an ecosystem-based strategy for protecting the resource base associated with much of Maryland's economy.

INRA utilizes GIS and related information to characterize watershed and other landscape units based on ecological and socioeconomic condition and stress information derived from a variety of sources. This information is then interpreted and applied based on agency programmatic goals and objectives.

The assessment tool has matured to the point that it is now being used for conservation and restoration targeting applications at multiple spatial scales. This presentation will summarize the current status of INRA and focus on its use in Maryland's Clean Water Action Plan and in the evaluation of a statewide greenways system.

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